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NATIONAL DAM SAFETY PROGRAM. WELLS LAKE DAM (MO 30906), MISSISS--ETC(U)
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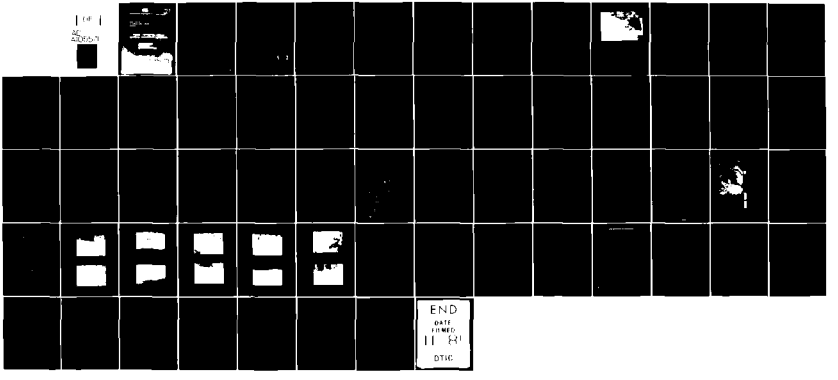

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Richard G. Bowker
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This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Wells Lake Dam (MO 30906)

This report presents the results of field inspection and evaluation of the Wells Lake Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED: SIGNED
Chief, Engineering Division

01 APR 1981
Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer

03 APR 1981
Date

WELLS LAKE DAM

St Francois County, Missouri

Missouri Inventory No. 30906

Phase I Inspection Report

National Dam Safety Program

Prepared by

Woodward-Clyde Consultants

Chicago, Illinois

Under Direction of

St Louis District, Corps of Engineers

for

Governor of Missouri

January 1981

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Wells Lake Dam
State Located	Missouri
County Located	St Francois
Stream	Unnamed Tributary of Hazel Run
Date of Inspection	11 November 1980

Wells Lake Dam, Missouri Inventory No. 30906, was inspected by Richard Berggreen (engineering geologist), Leonard Krazynski (geotechnical engineer), and Sean Tseng (hydrologist). The dam is an earth dam constructed for recreational purposes.

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession. These guidelines are intended to provide for an expeditious identification of those dams which may pose hazards to human life or property, based on available data and a visual inspection. In view of the limited scope of the study, no assurance can be given that all deficiencies have been identified.

The St Louis District, Corps of Engineers (SLD) has classified this dam as having a high hazard potential. The potential damage zone length estimated by the SLD extends approximately one and one-half miles downstream of the dam. Within this zone are three occupied dwellings, an abandoned school , and assorted farm buildings. Because of the proximity of the occupied buildings downstream, particularly the abandoned school which is occasionally used for meetings, it is recommended that 100 Percent of the Probable Maximum Flood (PMF) be used as the spillway design flood. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

Wells Lake Dam is in the small size classification, based on its maximum height of 28 ft and on its reservoir storage volume of approximately 130 ac-ft. The small dam classification includes dams between 25 and 40 ft in height or having storage volumes between 50 and 1000 ac-ft.

Our inspection and evaluation indicate the dam to be in generally good condition. This evaluation is primarily based on the absence of slumping, cracks, erosion, animal burrows and major seepage. The hydrologic analyses indicate that a flood greater than 81 percent of the PMF will effectively overtop the dam. Overtopping occurs only over the end of the compacted earth embankment at the right abutment, adjacent to the main spillway depression. The dam will not be overtopped by the 1 percent probability-of-occurrence (100 year) flood event. The 1 percent probability of occurrence event is defined as the flood that has 1 percent chance of occurring in any one year, or once in every 100 years.

The downstream channel contains many trees and bushes. The auxiliary spillway discharge channel is obstructed by bushes and trees. Gulley erosion is occurring where the main spillway discharge channel traverses steeper slopes about 130 ft downstream of the main spillway. This gully erosion does not presently cause a serious threat to the safety of the dam.

Based on our evaluation of the information obtained from the visual inspection and other available information, the following specific recommendations are made for Wells Lake Dam:

1. Trees and large bushes in the auxiliary spillway discharge channel should be removed to avoid the possibility of creating an obstruction to flow. The need to raise the low edge of this channel, or deepen the channel, to keep flood flows away from the toe of the dam, should be investigated.

2. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" should be performed by an engineer experienced in the design and construction of earth dams.

3. Investigation should be made of the feasibility of a warning system to alert downstream residents, should potentially hazardous conditions develop at the dam during periods of heavy precipitation.

4. A program of periodic inspections should be developed and implemented. This program should identify, as a minimum, evidence of instability such as cracking or slumping on the embankment, and should monitor seepage from the toe of the dam.

Changes in conditions such as increased seepage volume or turbidity in the seepage water should be evaluated. Maintenance should include maintaining the spillway discharge channel and downstream channel free of potential obstructions such as trees and bushes. Erosion in the discharge channels should also be monitored to detect any change in conditions that could lead to a decrease in the safety of the dam. If erosion increases or becomes a hazard to the safety of the dam, erosion protection measures should then be taken. Records of the inspections and maintenance should be kept.

The owner is recommended to take action as soon as practical to avoid deterioration of this facility. All remedial measures, inspections and maintenance should be evaluated and/or performed by an engineer experienced in the design and construction of earth dams.

WOODWARD-CLYDE CONSULTANTS

Richard G. Berggreen
Registered Geologist

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OVERVIEW
WELLS LAKE DAM

MISSOURI INVENTORY NUMBER 30906

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
WELLS LAKE DAM, MISSOURI INVENTORY NO. 30906

SECTION 1
PROJECT INFORMATION

1.1 General

a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of the Wells Lake Dam, Missouri Inventory Number 30906.

b. **Purpose of investigation.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures and conclude if additional studies, investigations and analyses are necessary and warranted" (Chapter 3, "Recommended Guidelines for Safety Inspection of Dams").

c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams," Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, "Engineering and Design National Program for Inspection of Non-Federal Dams," prepared by the Office of Chief of Engineers, Department of the Army, and "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams," prepared by the St Louis District, Corps of Engineers (SLD). These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 Description of Project

a. **Description of dam and appurtenances.** Wells Lake Dam is an earth dam approximately 280 ft long and 28 ft in height (Fig 3-A and 3-B), impounding a lake used for recreational purposes. The embankment is grass-covered on the crest and downstream face. The main spillway is located at the right abutment (as the observer faces downstream). An auxiliary spillway is located at the left abutment. There are no control structures in either spillway, and no low level outlets were identified at this dam. The spillways are grass-lined. The discharge channel for the main spillway has apparently experienced flood flows in the past and has been eroded as much as 4 ft deep. No evidence of past flow through the auxiliary spillway was identified in the field inspection.

b. **Location.** The dam is located on an unnamed tributary of Hazel Run, approximately six miles northeast of Bonne Terre, in St Francois County, Missouri. The dam is in Section 26, T38N, R5E, on the USGS French Village (1964) 7.5-minute quadrangle map (Fig 1).

c. **Size classification.** The dam is classified small based on its height of 28 ft and storage volume of approximately 130 ac-ft. The small dam classification includes dams between 25 and 40 ft in height, or having storage volumes between 50 and 1000 ac-ft.

d. **Hazard classification.** The St Louis District, Corps of Engineers (SLD), has classified this dam as having a high hazard potential; we concur with this classification. The SLD estimated damage zone length extends approximately one and one-half miles downstream. An abandoned school, occasionally used for community meetings, three occupied dwellings and assorted farm buildings are located in the estimated damage zone. The downstream hazards were verified by aerial reconnaissance and on the ground by the inspection team.

e. **Ownership.** The dam is reportedly owned by Mr Charles Wells, Route 1 Box 108, Bonne Terre, Missouri, 63628. Correspondence should be sent to his attention. At the time of inspection, Mr Wells maintained a residence in the immediate vicinity of the dam and was present during the inspection.

f. **Purpose of dam.** The reservoir impounded by the dam is used for recreational purposes.

g. **Design and construction history.** Information on the design and construction of the dam was obtained from Mr Wells. No construction reports were available.

Mr Wells indicated the dam was constructed based on design recommendations from the US Soil Conservation Service (SCS). The SCS office in Columbia, Missouri, was contacted and supplied the available information from their files. A preliminary design was included but no records were available on whether the dam was constructed to these specifications. Pertinent design data are included in Appendix C.

The dam was reported by Mr Wells to have been constructed by N. C. Shelly Excavating Company, Luddington, Missouri, in 1972. The dam was reported to be founded on shallow bedrock. No other information was available on the construction of the dam.

h. **Normal operating procedures.** There are no facilities requiring operation at this dam. Flood flows pass over the uncontrolled spillways at the right and left abutments.

1.3 Pertinent Data

a. **Drainage area.** 0.09 mi^2

b. **Discharge at dam site.**

Maximum known flood at dam site	Unknown
Warm water outlet at pool elevation	N/A
Diversion tunnel low pool outlet at pool elevation	N/A
Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation	530 ft^3/sec
Total spillway capacity at maximum pool elevation	530 ft^3/sec

c. **Elevations (ft above MSL).**

Top of Dam	882.6 to 884.1
Maximum pool - design surcharge	N/A
Full flood control pool	N/A
Recreation pool	879.9
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	Unknown
Maximum tailwater	Unknown
Toe of dam at maximum section	855.7

d. **Reservoir.**

Length of maximum pool	500 ft
Length of recreation pool	450 ft
Length of flood control pool	N/A

e. **Storage (acre-feet).**

Recreation pool	110
Flood control pool	N/A
Design surcharge	N/A
Top of dam	130

f. **Reservoir surface (acres).**

Top of dam	9.2
Maximum pool	9.2
Flood control pool	N/A
Recreation pool	8.0
Spillway crest	8.0

g. **Dam.**

Type	Earth
Length	280 ft
Height	28 ft
Top width	7 ft
Side slopes	Upstream 3.3(H) to 3.5(H): 1(V) on exposed portion (designed at 4(H): 1(V)) Downstream 2.6(H) to 2.9(H): 1(V)
Zoning	Unknown, probably none
Impervious core	Unknown, probably none
Cutoff	Probably trench to shallow bedrock
Grout curtain	Unknown, probably none

h. **Diversion and regulating tunnel.**

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating facilities	N/A

i. **Spillway.**

	Main	Auxiliary
Type	Unlined earth, triangular, uncontrolled, at right abutment	Unlined earth, trapezoidal, uncontrolled, at left abutment
Length of weir	69 ft (at el 882.6)	24 ft (at el 882.6)
Crest elevation	879.9 ft (MSL)	880.6 ft (MSL)
Gates	None	None
Downstream channel	Channel deeply eroded in soil. Relatively unobstructed.	Broad, ill-defined channel along left abutment, potentially obstructed by brush and trees.

j. **Regulating outlets.** None

SECTION 2
ENGINEERING DATA

2.1 Design

Mr Wells, owner of the dam, reported the dam was built according to US Soil Conservation Service (SCS) design. The Columbia, Missouri office of SCS was contacted and supplied the available information from their files. This information is presented in Appendix C.

The SCS design information is only a preliminary design. No records are available on the "as-built" configuration of the dam, and no records are available documenting SCS inspections during dam construction.

2.2 Construction

No construction reports were available for this dam. Mr Wells reported the dam was constructed in 1972 by N. C. Shelly Excavating Company of Luddington, Missouri. The foundation for the dam was reported by Mr Wells as excavated to shallow bedrock. The dam was constructed of locally obtained clayey soil. No records were available regarding materials tests on embankment soils or on compaction testing of the embankment construction.

2.3 Operation

There are no facilities requiring operation at this dam. There are no records of quantities of flow through the spillways.

2.4 Evaluation

a. **Availability.** Preliminary design data were obtained through the Columbia, Missouri, office of the SCS. Other information was obtained orally from Mr Wells, the owner of the dam.

b. **Adequacy.** The available engineering data and information are insufficient to evaluate the design of Wells Lake Dam. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" are not on record. This is a deficiency which should be rectified. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record. These analyses should be performed by an engineer experienced in the design and construction of earth dams.

c. **Validity.** The information obtained from the SCS and Mr Wells appears factual and does not disagree with the observations made during the visual inspection. However, the information is incomplete.

2.5 Project Geology

The dam site is located on the northeast flank of the Ozark structural dome. The regional dip is to the northeast. The bedrock in the area is mapped on the Geologic Map of Missouri (1979) as Cambrian age Elvins Group, probably Derby-Doerun Formation (Fig 4). The Derby-Doerun Formation is thin-bedded dolomite with interbedded silty glauconite shale. The soil developed in the area contains an abundance of quartz druse, typical of the overlying Potosi Formation. The Potosi Formation is a medium- to fine-grained, light brownish-gray dolomite with abundant chert and quartz druse typical of chert-bearing formations. The contact between the Derby-Doerun and Potosi Formations occurs in the vicinity of the elevation of the dam, and the soil may be a mixture of the residuum developed from these two formations.

The soil is a gravelly to silty clay (CL). The gravel fraction consists of angular chert and quartz druse fragments, from coarse sand to small pebble size. The fine fraction is predominantly a moderately plastic, reddish-brown silty clay. This soil appears to be moderately erodible where exposed in the main spillway discharge channel. The soil is mapped on the Missouri General Soils Map (1979) as Peridge-Cantwell-Gasconade Soil Association.

The dam site is located less than one mile north of a fault which runs north-northwest between the Valle Mines-Vineland Fault Zone to the north and the Big

River Fault System to the south. The fault is mapped as approximately seven miles long, with displacement on the fault as northeast side up. This fault, like most others in the Ozark area, is within the Precambrian and Paleozoic bedrock units and is not considered to be in a seismically active area. The fault is not considered to pose a significant hazard to the dam.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. **General.** A visual inspection was made of the Wells Lake Dam on 11 November, 1980. Mr Charles Wells, the dam owner, met with the inspection team and was present during the inspection. This inspection indicated the dam is in generally good condition.

b. **Dam.** The embankment is constructed of locally-obtained soil. The embankment soil was sampled and classified in the field as a gravelly silty clay (CL), the gravel fraction consisting primarily of quartz druse. The fine fraction is a reddish-brown, moderately plastic, silty clay, apparently the insoluble residue developed from the carbonate bedrock. The soil appears to have a moderate erosion potential due to its cohesion and good vegetative cover. However, erosion sufficient to pose a hazard to the dam could occur if the embankment were overtopped to a significant depth for a long duration. Vegetation on the dam crest and downstream slope consists of grass, weeds and small berry bushes (Photo 1). The upstream slope of the dam is unvegetated below the high water line (Photo 2) and has experienced some erosion of the fine soil, leaving lag gravel. Continued wave erosion of the upstream face is not anticipated to be severe due to the erosion protection offered by the lag gravel and the short fetch of the reservoir to develop waves.

The dam crest did not show any evidence of disruption of the vertical or horizontal alignment (Photo 3). No evidence was noted of cracking, slumping or excessive settlement of the embankment slopes, sinkhole development, or animal burrows. No evidence of significant erosion was noted on the embankment, except the minor wave erosion noted on the upstream slope.

A small pool and marshy ground was noted at the toe of the dam, apparently the result of slow seepage from the base of the dam (Photos 4 and 5). No movement of water was apparent and seepage was estimated at less than 1 gal/min. The water did not appear to be transporting any soil.

c. **Appurtenant structures.**

1. Main spillway. The main spillway is located at the right abutment (as the observer faces downstream). The spillway consists of a broad triangular notch cut into the natural soil (Photo 6). The area is grass-lined and showed evidence of having carried flood flows in the past. The spillway is located immediately adjacent to the end of the compacted dam embankment, and severe erosion in the spillway could pose a safety hazard to the dam.

2. Auxiliary spillway. The auxiliary spillway is located at the left abutment (Photos 3 and 7). This spillway is a shallow trapezoidal notch at the end of the dam. It is grass-lined and showed no evidence of having carried flood flows in the past. The relatively gentle slope downstream of this spillway suggests that velocities sufficient to cause erosion are not likely to be achieved in the spillway.

d. **Reservoir area.** The slopes surrounding the reservoir are relatively flat, less than 5(H) to 1(V). The area is at present pasture and woodland and not likely to contribute significant sediment to the reservoir. No evidence of siltation of the reservoir was noted during the visual inspection, and no measurements of siltation were available.

At one area on the eastern margin of the reservoir, the lake level is within approximately 3 ft in elevation of the ridge top separating the lake from the next drainage to the east (Photo 8). It may be possible to grade this area to act as an emergency spillway. However, additional detailed surveying and hydrologic analysis would be necessary to calculate the size and depth of this potential emergency spillway.

e. **Downstream channel.** The downstream channel below the main spillway is unlined and supports a growth of grass and low weeds. The channel is approximately 20 ft from the toe of the slope of the embankment. The

upper reaches of the channel (first 80 ft) flow south from the spillway at a relatively gentle slope. Along its middle reaches, the channel flows down the hillside at a relatively steep slope and has eroded a gully as much as 4 ft deep (Photo 9). Headward erosion of this channel can be anticipated during flood flows. This erosion should be monitored and protection should be added when needed to prevent erosion from progressing uphill into the spillway area. The lower portion of this channel has a relatively gentle slope to where it meets the original streambed. Erosion is unlikely in this area.

The downstream channel below the auxiliary spillway has a generally flat slope, and is not likely to experience velocities sufficient to cause serious erosion. The middle and lower reaches of this channel are overgrown with brush and trees and could become obstructed during flooding (Photo 7).

3.2 Evaluation

The results of the visual inspection indicate the dam is in generally good condition. No evidence was noted of disruption of the vertical or horizontal alignment of the dam, slumping or cracking of the embankment slopes, sinkhole development or animal burrows. No significant erosion was noted on the dam slopes. A deep gully has been eroded in the discharge channel approximately 130 ft downstream from the main spillway. This area should be monitored and may in time require erosion control measures to prevent headward erosion into the spillway area. No evidence of past flows were noted in the auxiliary spillway. Seepage at the toe of the dam, estimated at less than 1 gal/min, was indicated by a small pool. No soil was noted in the seepage water, and the seepage is not considered to pose a hazard to the dam at this time. The grass and brush vegetation on the downstream slope and crest of the dam appears to provide adequate erosion protection for normal operating conditions. There is no erosion protection on the upstream face of the dam, but the short fetch of the reservoir would develop only small waves and protection may not be necessary.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

No facilities requiring operation were identified at this dam site. Water level in the reservoir is controlled by the elevations of the ungated spillways. Normal operating procedure is to allow natural drainage through the main spillway.

4.2 Maintenance of the Dam

No records of maintenance were located for this dam.

4.3. Maintenance of Operating Facilities

No facilities requiring operation exist at this dam.

4.4 Description of Any Warning System in Effect

A warning system was not identified in the inspection.

4.5 Evaluation

There is no formal maintenance program in effect for this dam. The main spillway discharge channel may require future maintenance to provide erosion control. The development of a maintenance program and an evaluation of a practical and effective warning system are recommended for this facility.

SECTION 5
HYDROLOGY/HYDRAULICS

5.1 Evaluation of Features

a. **Design data.** No hydrologic or hydraulic design data were available for evaluation of this dam or reservoir; however, dimensions of the dam were surveyed. Survey data were provided by James F. McCaul, III, and Associates, Consulting Engineers/Land Surveyors, Potosi, Missouri. The data are presented in Fig 3-A and 3-B. Other relevant data were measured during the visual inspection or estimated from topographic mapping. The map used in the analysis was the USGS French Village 7.5-minute quadrangle map (1964).

b. **Experience data.** No recorded rainfall, runoff, discharge or pool stage historical data were found for this reservoir.

c. **Visual observations.**

1. Watershed. The watershed is covered with natural woods, forested with mixed hardwoods and softwoods, and some open pasture. The area of the reservoir is approximately 13 percent of the total drainage area of 0.09 mi^2.

2. Reservoir. The reservoir and dam are best described by the maps and photographs enclosed herewith. The primary use of this impoundment is for recreation.

3. Spillway. The main spillway is at the west end of the dam embankment abutting the natural hillside. The auxiliary spillway is at the east end. Both spillways are unlined and ungated. The main spillway is approximately triangular in shape; the auxiliary spillway is approximately trapezoidal. The gradients in the discharge channels below the spillways indicate that both spillways act as control sections for flow. One edge of the auxiliary spillway discharge channel is only 0.9 ft above the bottom of the spillway channel (Section F-F, Fig 3-B). During high flows, water may flow out of the channel at this point and along the downstream toe of the dam. Subsequent erosion of the toe could endanger the stability of the dam.

4. Seepage. The magnitude of seepage through this dam is very small and not hydrologically significant to the overtopping potential.

d. **Overtopping potential.** One of the primary considerations in the evaluation of Wells Lake Dam is the assessment of the potential for overtopping and possible consequent failure by erosion of the embankment. Since the spillways of this dam are unlined, deep erosion at the control sections of the spillways due to high velocity discharge is expected to be a major consideration. For this evaluation the lowest portion of the dam embankment, which is adjacent to the west spillway (main spillway), was considered to be the top of dam for the purpose of determining the overtopping potential.

Hydrologic analysis of this dam for the 1 and 10 percent probability-of-occurrence and Probable Maximum Floods (PMF) were all based on initial water surface elevations equal to the main spillway crest elevation. This is supported by the field survey which established that the high water mark is slightly above that of the main spillway crest. The results of the analysis indicate that a flood of greater than 81 percent of the PMF will effectively overtop the dam. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The analysis also indicates that the spillway will pass the 1 percent probability-of-occurrence flood (100-yr flood) without overtopping the dam. The combined spillway capacity at maximum pool elevation is approximately 530 ft^3/sec.

The following overtopping data for the PMF ratio storms were computed for the dam:

Precipitation Event	Max. Reservoir W.S. Elev., ft, MSL	Max. Depth Over Dam, ft	Max. Outflow, ft^3/sec	Duration of Overtopping, hrs
50% PMF	882.0	0.0	290	0.0
81% PMF	882.6	0.0	530	0.0
100% PMF	882.9	0.3	680	0.5

It should be noted that at the PMF the depth of overtopping will reach nearly 0.3 feet and the low portion of the compacted embankment will be overtopped for approximately 0.5 hour. Velocity over the compacted embankment will be small and not likely to cause serious concern. However, velocity in portions of the main spillway may reach 6.5 ft/sec and in the auxiliary spillway the velocity may reach 4.3 ft/sec. These velocities will probably cause some erosion in the spillways.

Erosion has taken place in the main spillway downstream discharge channel in the past (Section 3.1e; Photo 9) and is likely to continue during significant flood flows. This erosion should be monitored to prevent erosion from becoming a hazard to the safety of the dam.

Because of the short distance to the occupied buildings downstream and the fact that the spillway could be made to pass 100 percent of the PMF with relatively minor alteration, it is recommended that the spillway design flood be 100 percent of the PMF.

Input data and output summaries for the hydrologic and hydraulic analyses are presented in Appendix B.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual observations.** The visual inspection of Wells Lake Dam revealed that it is structurally in generally good condition. There was no evidence of lateral spreading or horizontal displacement of the dam crest. No evidence of sinkholes near the dam or in the surrounding area was noted. No cracking or slumping on the dam or in the area beyond the dam toe was identified. The downstream face was vegetated with grass and bushes. These grass and bushes will provide moderate erosion protection during normal operating conditions. The embankment could be subject to erosion, however, if the main embankment were overtopped.

The low volume seepage which was noted at toe of the dam did not appear to be transporting soil particles. This seepage should be monitored and the amount of flow and turbidity of the seepage should be periodically checked.

The spillways are in good condition at present. They are grass-lined and the erosion potential is judged to be moderate.

The main spillway discharge channel is in relatively good condition in the area near the dam. It is expected however, that erosion will continue in the downstream area indicated in Fig A-1, Appendix A. The channel is moderately erodible, and may therefore, require future erosion protection in the zone near the dam. The auxiliary spillway does not appear to have carried flood flows in the past. The downstream channel below the auxiliary spillway could become obstructed during flooding events. Flood flows would overtop the edge of the auxiliary spillway discharge channel if the depth of flow was greater than 0.9 ft. The overflow water would then flow along the downstream toe of the embankment endangering its stability.

During periods of high flows, the trees in the auxiliary spillway discharge channel could be toppled and obstruct flow. These trees should be removed, under the guidance of an engineer experienced in the design of earth dams. Indiscriminate clearing of trees could jeopardize the safety of the dam.

b. **Design and construction data.** No design or construction records were available for this dam. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available. All information on the construction of the dam was obtained through Mr Charles Wells, owner of the dam, and the Soil Conservation Service, and is recorded in Section 1.2g. of this report.

c. **Operating records.** No operating records or water level records are maintained for this facility.

d. **Post construction changes.** There have been no post construction changes on this dam other than the growth of grass and bushes on the downstream dam face and auxiliary discharge channel.

e. **Seismic stability.** The dam is in Seismic Zone 2 to which the guidelines assign a moderate damage potential. During a seismic event, liquefaction of the gravelly, silty clay dam material is unlikely. However, without knowledge of soil properties of the embankment materials, the seismic stability of the dam cannot be evaluated.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. **Safety.** Based on the visual inspection, the dam appears to be in generally good condition. No evidence of sinkholes, detrimental settlement, slides or lateral spreading of the dam was found. Seepage and stability analyses comparable to those required by the "Recommended Guidelines for Safety Inspections of Dams" were not on record, which is a deficiency that should be rectified. The hydraulic/hydrologic analyses of the spillway, dam, and the reservoir storage indicate that the dam will pass 81 percent of the PMF without overtopping. For this analysis the overtopping elevation was chosen at the beginning of the compacted embankment of the dam adjacent to the main spillway. Because this point is only overtopped by 0.3 ft for 0.5 hour for the PMF event, relatively minor remedial work will be necessary to allow passage of the PMF without overtopping the embankment.

b. **Adequacy of information.** The visual inspection provided sufficient information to support the recommendations presented in this Phase I investigation. The lack of design documents such as static and seismic stability analyses and seepage analysis precludes an evaluation of the static and seismic stability of the dam. This is a deficiency which should be corrected.

c. **Urgency.** The deficiencies described in this report could affect the safety of the dam. Remedial measures should be initiated as soon as practical.

d. **Necessity for Phase II.** In accordance with the "Recommended Guidelines for Safety Inspection of Dams," the subject investigation was a minimum study. This study revealed that additional in-depth investigations are needed to complete the assessment of the safety of the dam. Those investigations which should be performed as soon as practical are described in Section 7.2.b. It is our understanding from discussions with the SLD that any additional investigations are the responsibility of the owner.

7.2 Remedial Measures

a. **Alternatives.** There are several general options which may be considered to reduce the possibility of dam failure or to diminish the harmful consequences of such a failure. Some of these options are:

1. Remove the dam, or breach it to prevent storage of water.

2. Increase the height of dam and/or spillway size to pass the PMF without overtopping the dam.

3. Purchase downstream land that would be adversely impacted by dam failure, and restrict human occupancy.

4. Provide a highly reliable flood warning system (generally does not prevent damage but diminishes chances for loss of life).

b. **Recommendations.** Based on our inspection of the Wells Lake Dam, it is recommended that the following actions be taken as soon as practical:

1. Prepare a more detailed hydraulic/hydrologic analysis and design a spillway and discharge channel capable of passing 100 percent of the PMF without overtopping the embankment. The spillway should be protected to prevent erosion. The need to raise the edge of the auxiliary spillway discharge channel, or deepen the channel, in order to keep flood flows away from the toe of the dam, should be investigated.

2. Trees and large bushes in the auxiliary spillway discharge channel should be removed to avoid the possibility of creating an obstruction to flow.

3. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" should be performed.

4. Investigation should be made of the feasibility of a warning system to alert downstream residents should potentially hazardous conditions develop at the dam during periods of heavy precipitation.

All remedial measures should be evaluated and performed under the guidance of an engineer experienced in the design and construction of earth dams.

c. **O & M procedures.** As there are no operating facilities per se, it is recommended that a program of periodic inspections be developed and implemented as soon as practical. This program should identify, as a minimum, evidence of instability such as cracking or slumping on the embankment, and include monitoring of seepage from the toe of the dam. Changes in conditions such as increased seepage volume or turbidity in the seepage water should be evaluated. Maintenance should include maintaining the spillway discharge channels and downstream channels free of potential obstructions such as trees and bushes. Erosion in the discharge channels should also be monitored to detect any change in conditions that could lead to a decrease in the safety of the dam. If erosion increases or becomes a hazard to the safety of the dam, erosion protection measures should then be taken. Records of the inspections and maintenance should be kept.

All inspections and maintenance should be evaluated and/or performed by an engineer experienced in the design and construction of earth dams.

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McCracken, Mary H., 1971, Structural Features Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

Missouri Geological Survey, 1979, Geologic Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

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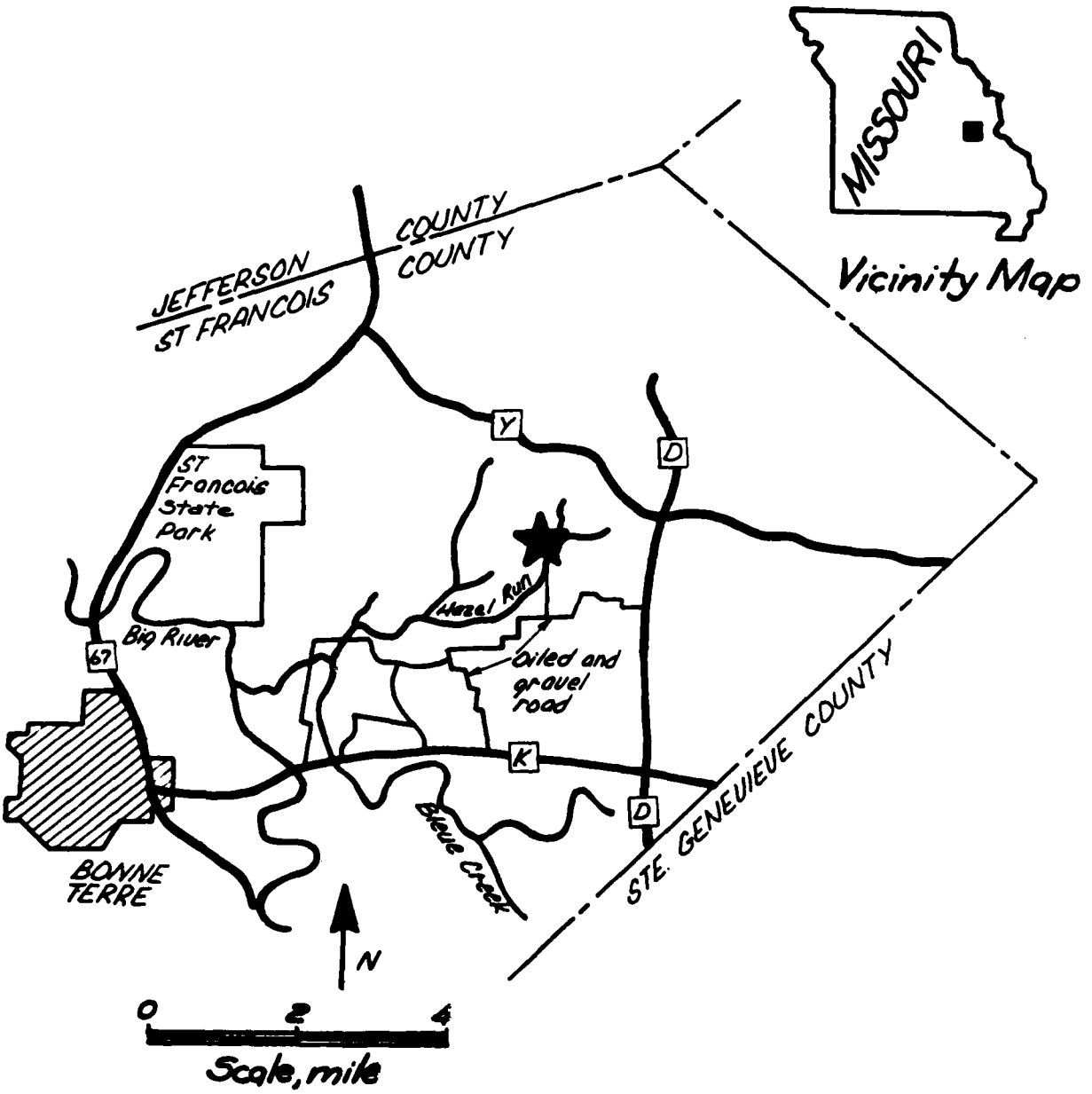
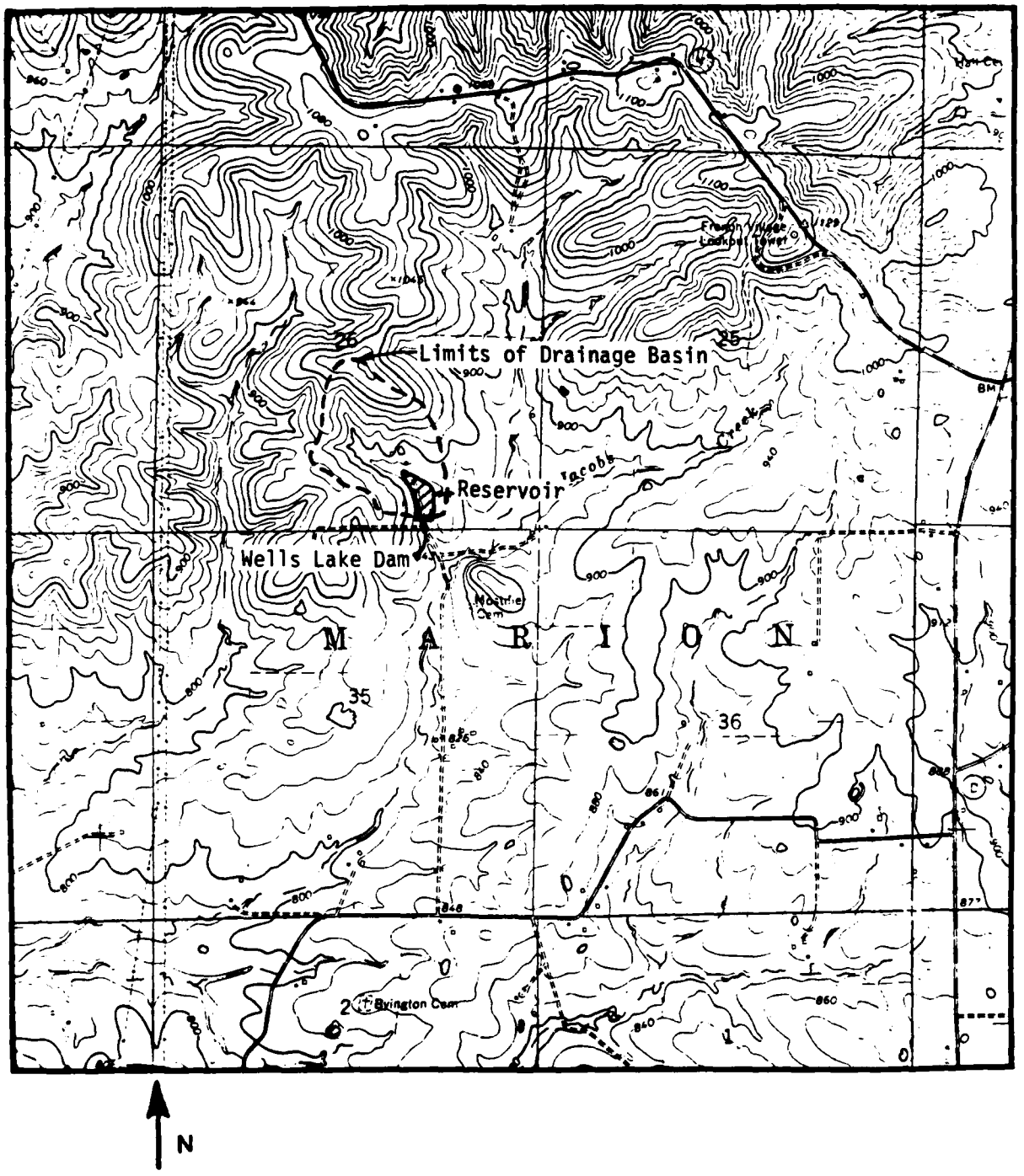
US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.



SITE LOCATION MAP

WELLS LAKE DAM

MO 30906 | Fig. 1



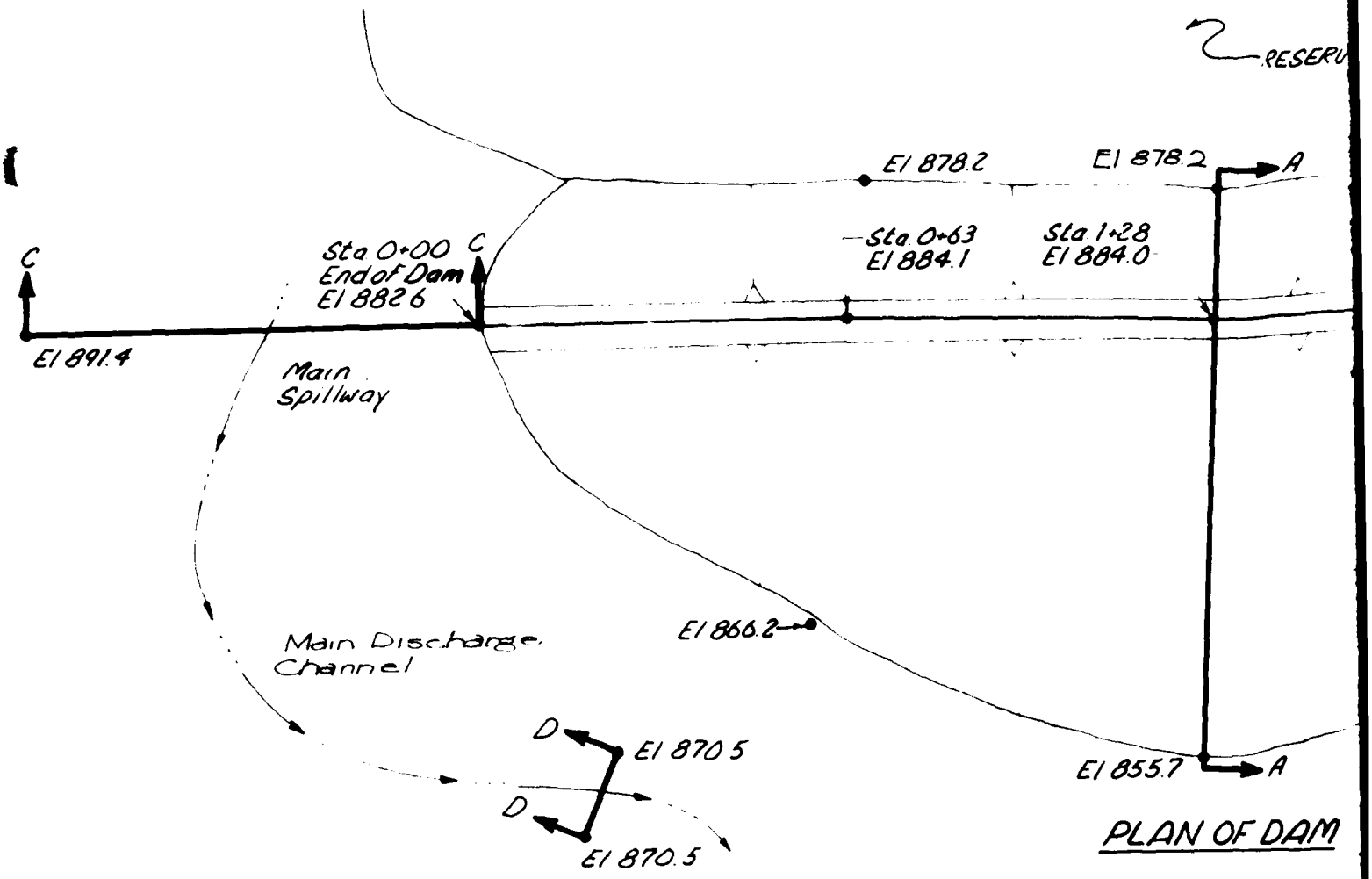
0 2000 4000

Scale, feet

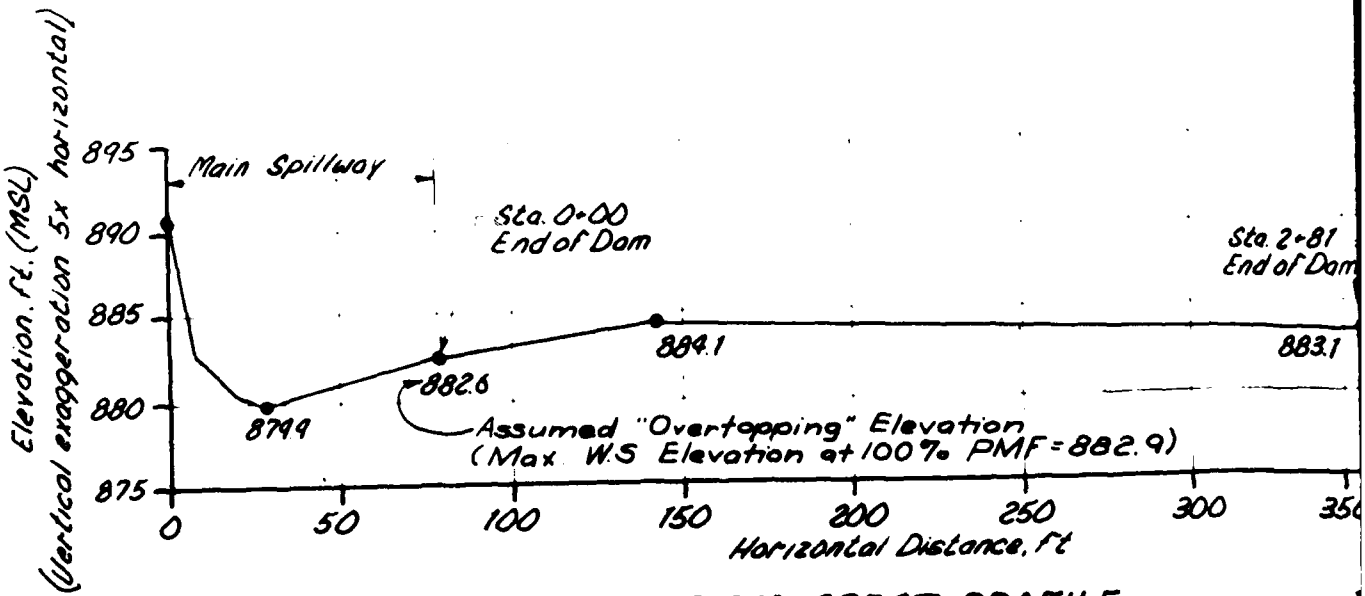
NOTE:
Topography from USGS French Village (1964) 7.5-minute quadrangle map.

DRAINAGE BASIN AND SITE TOPOGRAPHY

WELLS LAKE DAM	
MO 30906	Fig. 2

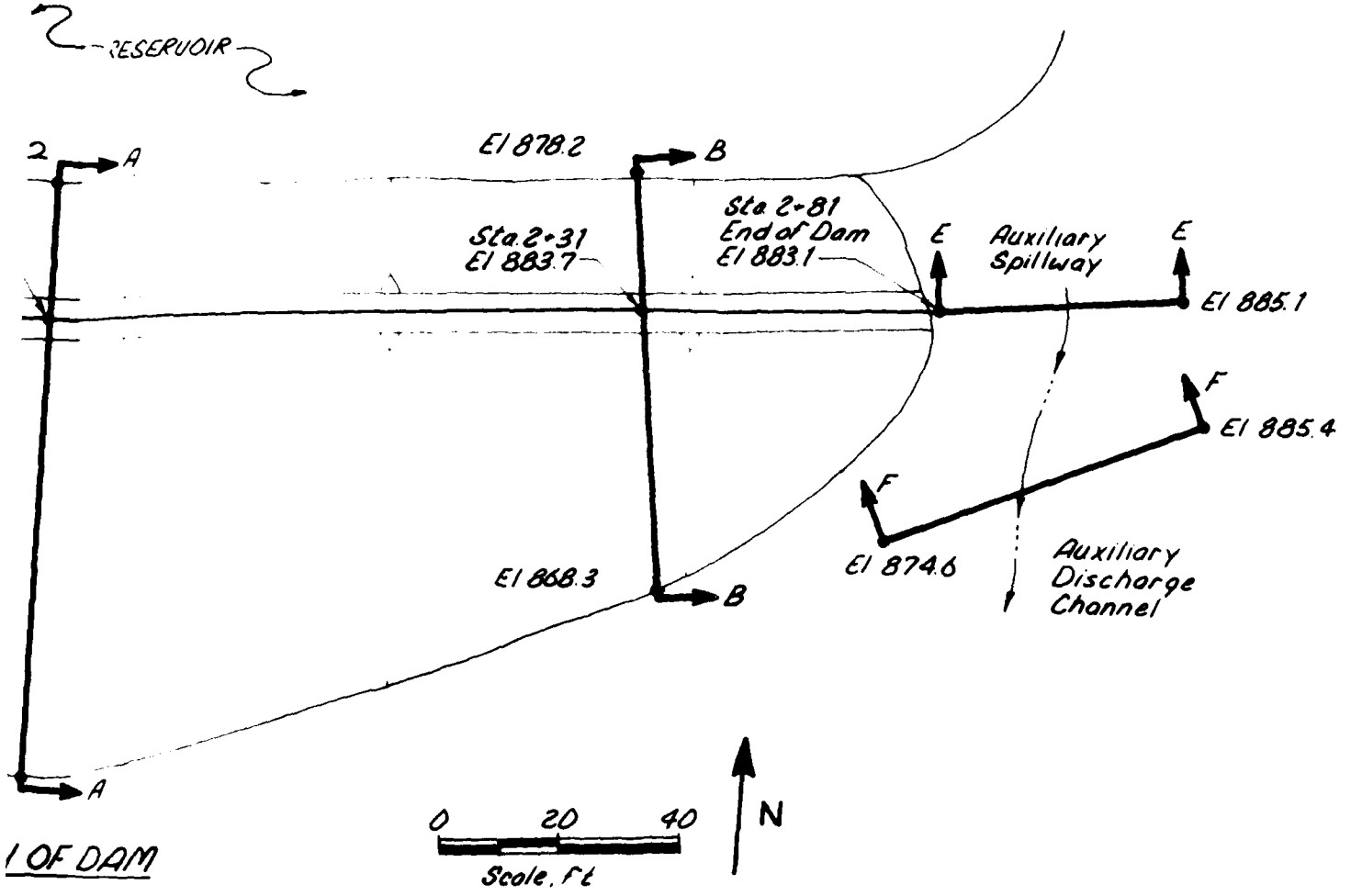


PLAN OF DAM

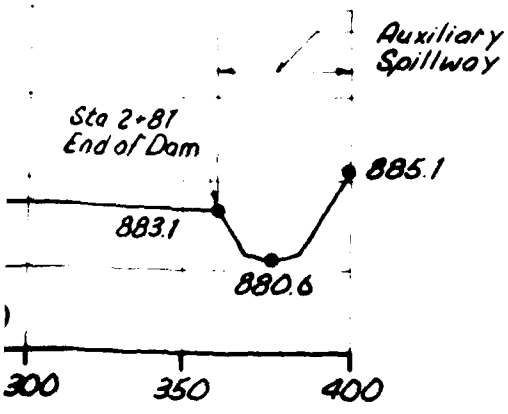


DAM CREST PROFILE

(Taken along centerline of dam and section C-C and E-E)

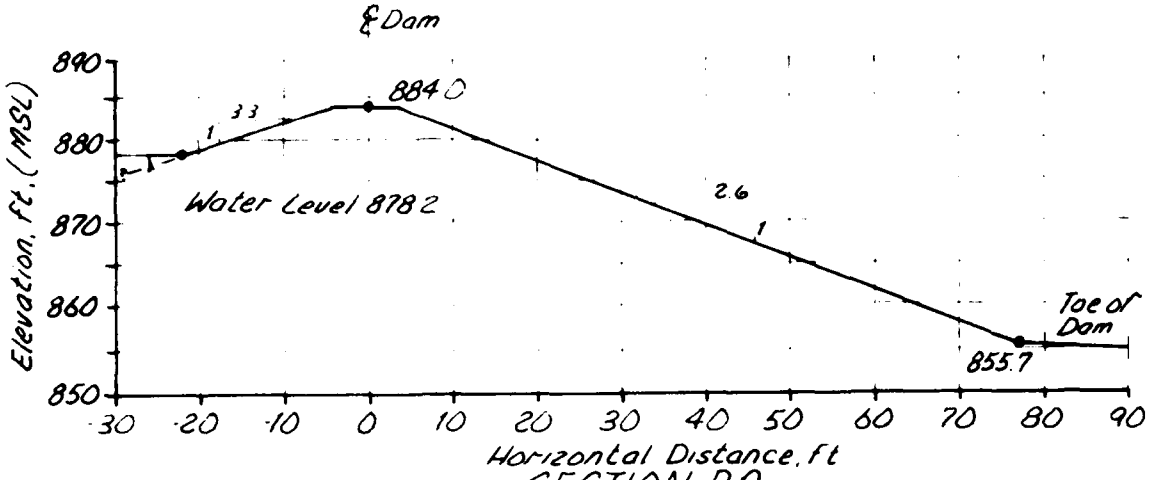


1 OF DAM

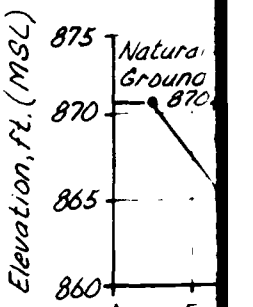


2

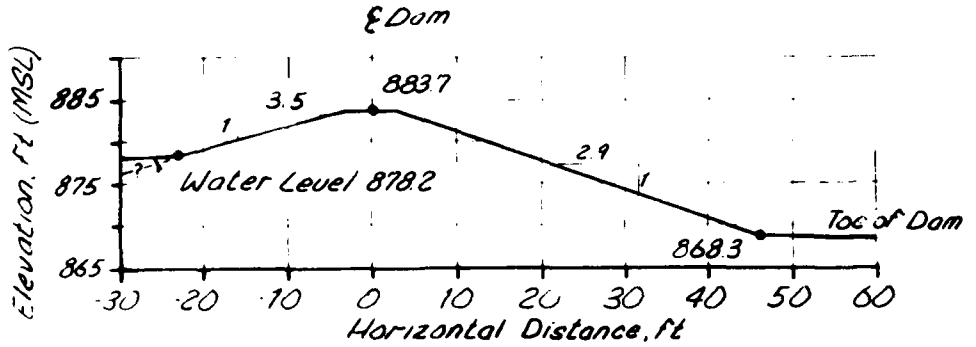
PLAN AND CREST PROFILE OF DAM	
WELLS LAKE DAM	
MO 30906	Fig. 3-A



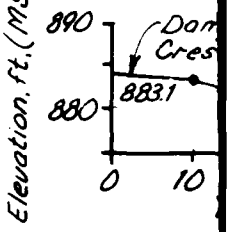
SECTION A-A
Maximum Dam Section

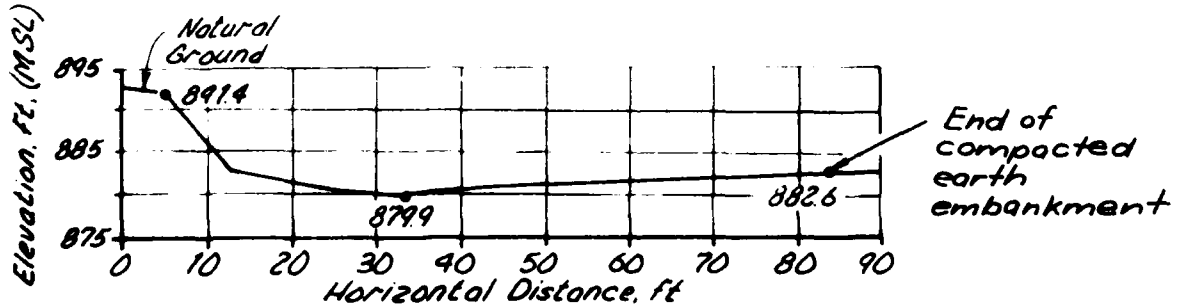


Discharge

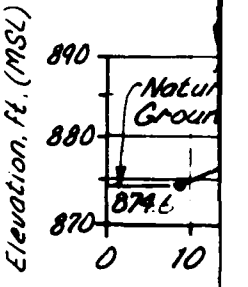


SECTION B-B
Dam Section

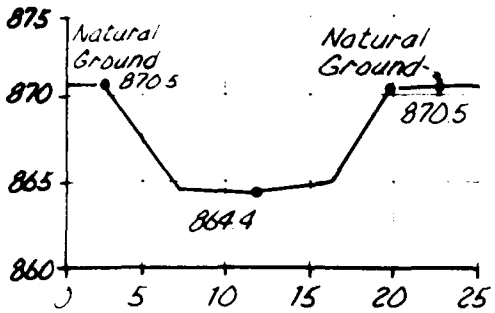




SECTION C-C
Main Spillway

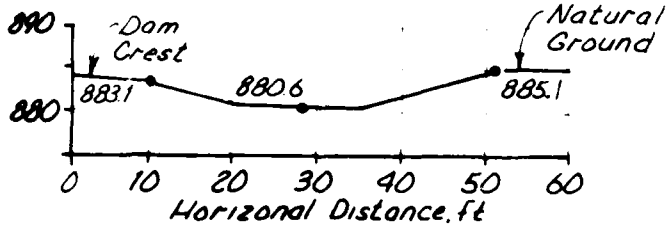


Discha



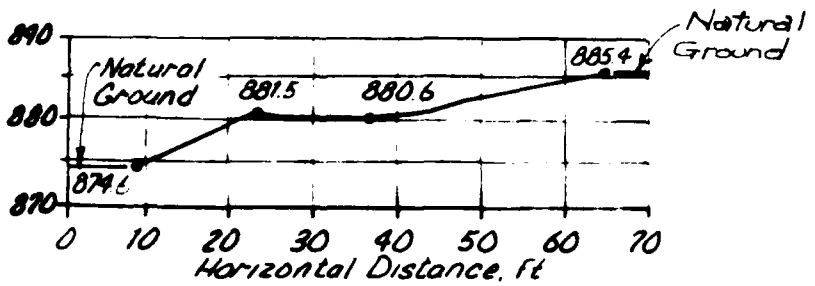
SECTION D-D

Discharge Channel of Main Spillway



SECTION E-E

Auxiliary Spillway



SECTION F-F

Discharge Channel of Auxiliary Spillway

J

SECTIONS OF DAM AND SPILLWAYS	
WELLS LAKE DAM	
MO 30906	Fig. 3-B

N

0 10 20

Scale, mile

Legend

Ojc — Smithville Formation
Powell Dolomite
Cotter Dolomite
Jefferson City Dolomite

Or — Roubidoux Formation

Gasconade Dolomite
Gunter Sandstone Member

Cep — Eminence Dolomite

Potosi Dolomite

Derby-Doerun Dolomite

Davis Formation

Bonneterre Formation
Whetstone Creek Member
Sullivan Siltstone Member

Reagan Sandstone

Lamotte Sandstone

Diabase (dikes and sills)

St. Francois Mountains Intrusive Suite

St. Francois Mountains Volcanic Supergroup

REGIONAL GEOLOGIC MAP

WELLS LAKE DAM

MO 30906 | **Fig. 4**

APPENDIX A

Photographs

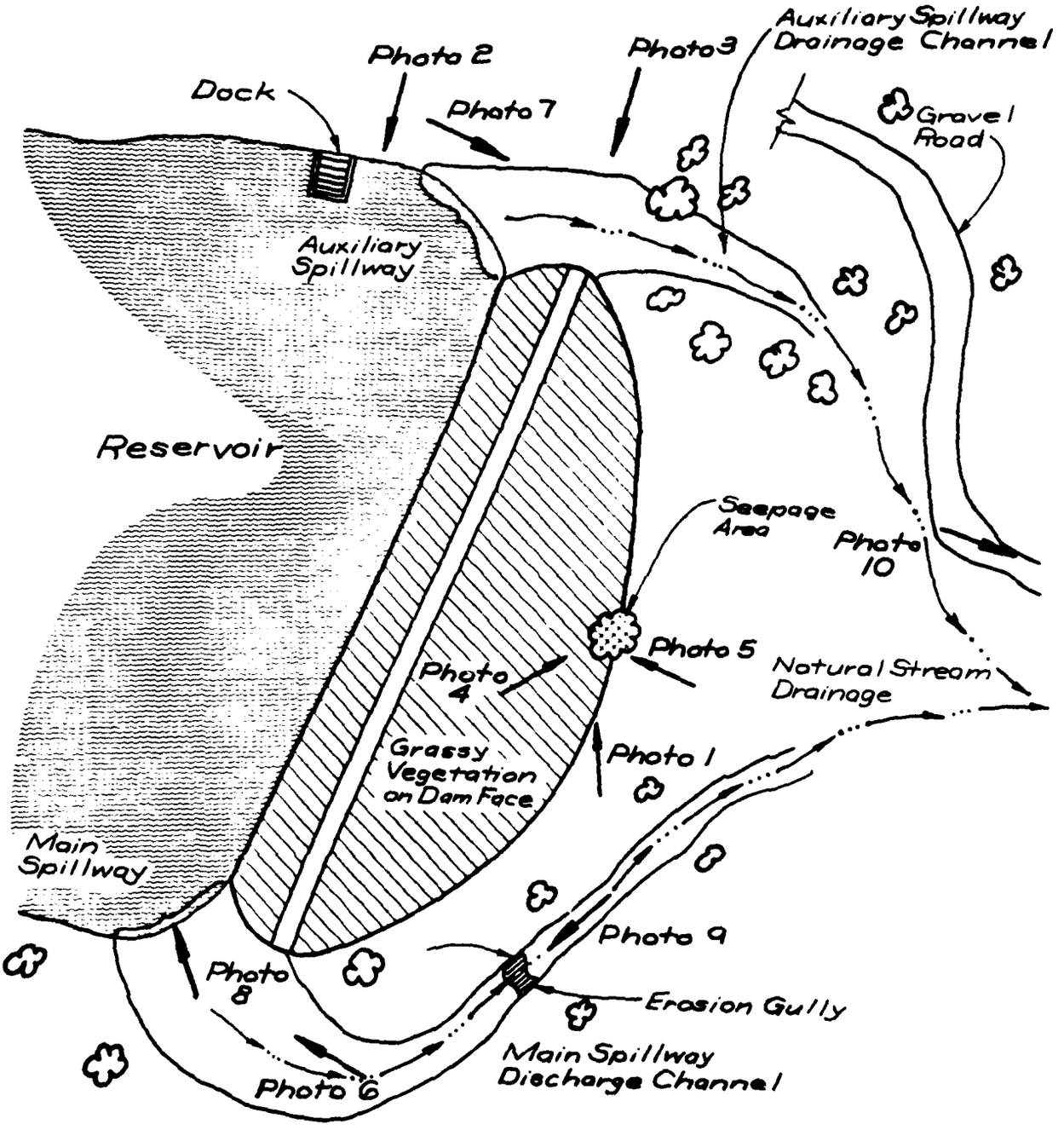


PHOTO LOCATION SKETCH

WELLS LAKE DAM	
MO 30906	Fig. A-1

1. Downstream face of Wells Lake Dam showing vegetation. Looking east.

2. Wave erosion on upstream face of Wells Lake Dam below high water mark. Looking west. Main spillway at far end of dam.

3. View along crest of dam from left abutment. Looking west. Person (in shadow, foreground) is standing in auxiliary spillway.

4. Tall water-grasses at toe of slope in area of seepage (center of photo). Looking southeast from downstream face of dam.

5. Seepage water pool at toe of dam.

6. Main spillway at right abutment. Dam embankment begins at right side of photo. Looking north (upstream). Discharge channel erosion (Photo 9) out of picture to the right.

7. Auxiliary spillway at left abutment. Looking south (downstream). Note trees in discharge channel in the distance.

8. Low area along east side of reservoir, possible area for emergency spillway. Looking northeast from main spillway.

9. Eroded gully in main spillway discharge channel. Dam is out of the picture to the right. Looking northwest (upstream).

10. Abandoned schoolhouse immediately downstream from Wells Lake Dam. Occassionally used for community gatherings but no longer used as a school. Looking south (downstream) from toe of dam.

APPENDIX B

Hydraulic/Hyrologic Data and Analyses

APPENDIX B
Hydraulic/Hydrologic Data and Analyses

B.1 Procedures

a. General. The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. The inflow hydrographs were developed for various precipitation events by applying them to a synthetic unit hydrograph. The inflow hydrographs were subsequently routed through the reservoir and appurtenant structures by the modified Puls reservoir routing option.

b. Precipitation events. The Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The total rainfall and corresponding distributions for the 1 and 10 percent probability events were provided by the St. Louis District, Corps of Engineers. The Probable Maximum Precipitation was determined from regional curves prepared by the US Weather Bureau (Hydrometeorological Report Number 33, 1956).

c. Unit hydrograph. The Soil Conservation Services (SCS) Dimensionless Unit Hydrograph method (National Engineering Handbook, Section 4, Hydrology, 1971) was used in the analysis. This method was selected because of its simplicity, applicability to drainage areas less than 10 mi^2, and its easy availability within the HEC-1 computer program.

The watershed lag time was computed using the SCS "curve number method" by an empirical relationship as follows:

$$L = \frac{\ell^{0.8}(s+1)^{0.7}}{1900\ Y^{0.5}} \qquad \text{(Equation 15-4)}$$

where: L = lag in hours
ℓ = hydraulic length of the watershed in feet = 2700
$s = \frac{1000}{CN} - 10 = 3.33$

CN = hydrologic soil curve number as indicated in Section B.2e.
Y = average watershed land slope in percent = 6.1.

This empirical relationship accounts for the soil cover, average watershed slope and hydraulic length.

With the lag time thus computed, another empirical relationship is used to compute the time of concentration as follows:

$$T_c = \frac{L}{0.6} \qquad \text{(Equation 15-3)}$$

where: T_c = time of concentration in hours

L = lag in hours.

Subsequent to the computation of the time of concentration, the unit hydrograph duration was estimated utilizing the following relationship:

$$\Delta D = 0.133 T_C \qquad \text{(Equation 16-12)}$$

where: ΔD = duration of unit excess rainfall
T_C = time of concentration in hours.

The final interval was selected to provide at least three discharge ordinates prior to the peak discharge ordinate of the unit hydrograph. For this dam, a time interval of 5 minutes was used.

d. Infiltration losses. The infiltration losses were computed by the HEC-1 computer program internally using the SCS curve number method. The curve numbers were established taking into consideration the variables of: (a) antecedent moisture condition, (b) hydrologic soil group classification, (c) degree of development, (d) vegetative cover and (e) present land usage in the watershed.

Antecedent moisture condition III (AMC III) was used for the PMF events and AMC II was used for the 1 and 10 percent probability events, in accordance with the guidelines. The remaining variables are defined in the SCS procedure and judgements in their selection were made on the basis of visual field inspection.

e. Starting elevations. Reservoir starting water surface elevations for this dam were set as follows:

(1) 1 and 10 percent probability events - main spillway crest elevation

(2) Probable Maximum Storm - main spillway crest elevation

f. Spillway Rating Curve. The HEC-2 computer program was used to compute the main spillway and auxiliary spillway rating curve using discharge channel cross sections and conveyance characteristics. The two rating curves were then manually combined and entered on the Y4 and Y5 cards.

B.2 Pertinent Data

a. Drainage area. 0.09 mi^2

b. Storm duration. A unit hydrograph was developed by the SCS method option of HEC-1 program. The design storm of 24 hours duration was divided into 5 minute intervals in order to develop the inflow hydrograph.

c. Lag time. 0.33 hr

d. Hydrologic soil group. C

e. SCS curve numbers.

1. For PMF- AMC III - Curve Number 88
2. For 1 and 10 percent probability-of-occurrence events - AMC II - Curve Number 75

f. Storage. Elevation-area data were developed by planimetering areas at various elevation contours on the USGS French Village 7.5-minute quadrangle map. The data were entered on the $A and $E cards so that the HEC-1 program could compute storage volumes.

g. Outflow over dam crest. As the profile of the dam crest is irregular, flow over the crest was computed according to the "Flow Over Non-Level Dam Crest" supplement to the HEC-1 User's Manual. The crest length-elevation data and hydraulic constants were entered on the $D, $L, and $V cards.

h. Outflow capacity. The combined spillway rating curve was developed from the cross section data of the spillways and the downstream channels, using the HEC-2 backwater program. The results of the above were entered on the Y4 and Y5 cards of the HEC-1 program.

i. Reservoir elevations. For the 50 and 100 percent of the PMF events, the starting reservoir elevation was 879.9 ft, the main spillway crest elevation. For the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was 879.9 ft, the main spillway crest elevation.

B.3 Results

The results of the analyses as well as the input values to the HEC-1 program follow in this Appendix. Only the results summaries are included, not the intermediate output. Complete copies of the HEC-1 output are available in the project files.

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION     JULY 1978
 LAST MODIFICATION  26 FEB 79
**********
     1                A1       WELLS LAKE, DAM NO. 30906, ST. FRANCOIS COUNTY, MISSOURI.
     2                A2       WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 80C224.
     3                A3       PROBABLE MAXIMUM FLOODS.
     4                B   288       0       5       0       0       0       0       0       0       0
     5                B1    5
     6                J     1       2       1
     7                J1  .50    1.00
     8                K     0  INFLOW                                   1
     9                K1       INFLOW COMPUTATIONS, PMF.
    10                M     1       2    .09                           1.0
    11                P     0      26     102     120     130
    12                T                                          -1      -88              0.13
    13                M2            0.33
    14                X    -1    -.05       5
    15                K     1     DAM                                  1
    16                K1       FLOOD ROUTING AND OVERTOPPING ANALYSES
    17                Y                                  1       1
    18                Y1    1                                      -879.9      -1
    19                Y4 879.9   880.6    881.    881.5    882.    882.5    883.    883.5    884.    884.5
    20                Y4  885.    886.
    21                Y5    0.      20.     57.     145.    284.    480.     750.    1070.    1460.   1910.
    22                Y5 2420.    3400.
    23                SA    0.     2.7     5.3     8.0     9.1     9.2     14.1    20.2     24.3    28.4
    24                SE 859.7    860.    870.    879.9   880.    882.6    890.    900.     910.    920.
    25                SS 879.9
    26                SD 882.6     2.7     1.5
    27                SL    0.      12.     70.     205.    280.
    28                SV 882.5    883.    883.5   884.    884.5
    29                K    49
```

Input Data
Various PMF Events
Wells Lake Dam
MO 30906

B4

FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION JULY 1978
LAST MODIFICATION 26 FEB 79

RUN DATE= 81/01/04.
TIME= 13.43.18.

WELLS LAKE, DAM NO. 30906, ST. FRANCOIS COUNTY, MISSOURI.
WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 80C224.
PROBABLE MAXIMUM FLOODS.

JOB SPECIFICATION

NC	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
288	0	5	0	0	0	0	0	0	0

JOPER	NMT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 2 LRTIO= 1

RTIOS= .50 1.00

SUB-AREA RUNOFF COMPUTATION

INFLOW COMPUTATIONS, PMF.

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
INFLOW	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
1	2	.09	0.00	.09	1.00	0.000	0	0	0

PRECIP DATA

SPFE	PMS	P6	P12	P24	P48	P72	P96
0.00	24.00	102.00	120.00	130.00	0.00	0.00	0.00

LOSS DATA

STRKR	STRTL	CNSTL	ALSMX	RTIMP
-1.00	-35.00	0.00	0.00	.11

[illegible] -1.00 PERCENT CN = 98.00

UNIT HYDROGRAPH DATA

0. 0.

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.05	1	.01	.00	.01	0.	1.01	12.05	145	.22	.21	.01	88.
1.01	.10	2	.01	.00	.01	0.	1.01	12.10	146	.22	.21	.01	93.
1.01	.15	3	.01	.00	.01	0.	1.01	12.15	147	.22	.21	.01	98.
1.01	.20	4	.01	.00	.01	1.	1.01	12.20	148	.22	.21	.01	94.
1.01	.25	5	.01	.00	.01	1.	1.01	12.25	149	.22	.22	.01	101.
1.01	.30	6	.01	.00	.01	1.	1.01	12.30	150	.22	.22	.01	110.
1.01	.35	7	.01	.00	.01	1.	1.01	12.35	151	.22	.22	.01	127.
1.01	.40	8	.01	.00	.01	1.	1.01	12.40	152	.22	.22	.00	134.
1.01	.45	9	.01	.00	.01	1.	1.01	12.45	153	.22	.22	.00	135.
1.01	.50	10	.01	.00	.01	1.	1.01	12.50	154	.22	.22	.00	142.
1.01	.55	11	.01	.00	.01	1.	1.01	12.55	155	.22	.22	.00	148.
1.01	1.00	12	.01	.00	.01	1.	1.01	13.00	156	.22	.22	.00	147.
1.01	1.05	13	.01	.00	.01	1.	1.01	13.05	157	.27	.26	.00	145.
1.01	1.10	14	.01	.00	.01	1.	1.01	13.10	158	.27	.26	.00	152.
1.01	1.15	15	.01	.00	.01	1.	1.01	13.15	159	.27	.26	.00	158.
1.01	1.20	16	.01	.00	.01	1.	1.01	13.20	160	.27	.26	.00	162.
1.01	1.25	17	.01	.00	.01	1.	1.01	13.25	161	.27	.26	.00	167.
1.01	1.30	18	.01	.00	.01	1.	1.01	13.30	162	.27	.26	.00	172.
1.01	1.35	19	.01	.00	.01	1.	1.01	13.35	163	.27	.26	.00	176.
1.01	1.40	20	.01	.00	.01	1.	1.01	13.40	164	.27	.26	.00	177.
1.01	1.45	21	.01	.00	.01	1.	1.01	13.45	165	.27	.26	.00	179.
1.01	1.50	22	.01	.00	.01	1.	1.01	13.50	166	.27	.26	.00	180.
1.01	1.55	23	.01	.00	.01	1.	1.01	13.55	167	.27	.26	.00	181.
1.01	2.00	24	.01	.00	.01	1.	1.01	14.00	168	.27	.26	.00	181.
1.01	2.05	25	.01	.00	.01	2.	1.01	14.05	169	.33	.33	.00	183.
1.01	2.10	26	.01	.00	.01	2.	1.01	14.10	170	.33	.33	.00	186.
1.01	2.15	27	.01	.00	.01	2.	1.01	14.15	171	.33	.33	.00	192.
1.01	2.20	28	.01	.00	.01	2.	1.01	14.20	172	.33	.33	.00	200.
1.01	2.25	29	.01	.00	.01	2.	1.01	14.25	173	.33	.33	.00	208.
1.01	2.30	30	.01	.00	.01	2.	1.01	14.30	174	.33	.33	.00	214.
1.01	2.35	31	.01	.00	.01	2.	1.01	14.35	175	.33	.33	.00	219.
1.01	2.40	32	.01	.00	.01	3.	1.01	14.40	176	.33	.33	.00	222.
1.01	2.45	33	.01	.00	.01	3.	1.01	14.45	177	.33	.33	.00	224.
1.01	2.50	34	.01	.01	.01	3.	1.01	14.50	178	.33	.33	.00	226.
1.01	2.55	35	.01	.01	.01	3.	1.01	14.55	179	.33	.33	.00	227.
1.01	3.00	36	.01	.01	.01	3.	1.01	15.00	180	.33	.33	.00	228.
1.01	3.05	37	.01	.01	.01	3.	1.01	15.05	181	.40	.40	.00	226.
1.01	3.10	38	.01	.01	.01	3.	1.01	15.10	182	.40	.40	.00	224.
1.01	3.15	39	.01	.01	.01	4.	1.01	15.15	183	.40	.40	.00	221.
1.01	3.20	40	.01	.01	.01	4.	1.01	15.20	184	.50	.50	.00	220.
1.01	3.25	41	.01	.01	.01	4.	1.01	15.25	185	.71	.70	.00	247.
1.01	3.30	42	.01	.01	.01	4.	1.01	15.30	186	1.71	1.71	.01	294.
1.01	3.35	43	.01	.01	.01	4.	1.01	15.35	187	2.82	2.81	.01	359.
1.01	3.40	44	.01	.01	.01	4.	1.01	15.40	188	1.11	1.11	.00	398.
1.01	3.45	45	.01	.01	.01	4.	1.01	15.45	189	.71	.70	.00	377.
1.01	3.50	46	.01	.01	.01	4.	1.01	15.50	190	.60	.60	.00	322.
1.01	3.55	47	.01	.01	.01	4.	1.01	15.55	191	.40	.40	.00	322.
1.01	4.00	48	.01	.01	.01	4.	1.01	16.00	192	.40	.40	.00	282.
1.01	4.05	49	.01	.01	.01	5.	1.01	16.05	193	.31	.31	.00	287.
1.01	4.10	50	.01	.01	.01	5.	1.01	16.10	194	.31	.31	.00	278.
1.01	4.15	51	.01	.01	.01	5.	1.01	16.15	195	.31	.31	.00	441.
1.01	4.20	52	.01	.01	.01	5.	1.01	16.20	196	.31	.31	.00	285.
1.01	4.25	53	.01	.01	.01	5.	1.01	16.25	197	.31	.31	.00	234.
1.01	4.30	54	.01	.01	.01	5.	1.01	16.30	198	.31	.31	.00	258.

Output Summary
Various PMF Events
Wells Lake Dam
MO 30906

B6

1.01	6.40	56	.01	.01	.01	5.	1.01	16.40	200	.31	.31	.00	2[illegible].
1.01	6.45	57	.01	.01	.01	5.	1.01	16.45	201	.31	.31	.00	2[illegible].
1.01	6.50	58	.01	.01	.01	5.	1.01	16.50	202	.31	.31	.00	224.
1.01	6.55	59	.01	.01	.01	5.	1.01	16.55	203	.31	.31	.00	228.
1.01	6.60	60	.01	.01	.01	5.	1.01	17.00	204	.31	.31	.00	224.
1.01	6.65	61	.01	.01	.01	6.	1.01	17.05	205	.24	.24	.00	221.
1.01	6.70	62	.01	.01	.01	6.	1.01	17.10	206	.24	.24	.00	216.
1.01	6.75	63	.01	.01	.01	6.	1.01	17.15	207	.24	.24	.00	208.
1.01	6.80	64	.01	.01	.01	6.	1.01	17.20	208	.24	.24	.00	199.
1.01	6.85	65	.01	.01	.01	6.	1.01	17.25	209	.24	.24	.00	191.
1.01	6.90	66	.01	.01	.01	6.	1.01	17.30	210	.24	.24	.00	184.
1.01	6.95	67	.01	.01	.01	6.	1.01	17.35	211	.24	.24	.00	179.
1.01	6.60	68	.01	.01	.01	6.	1.01	17.40	212	.24	.24	.00	176.
1.01	6.65	69	.01	.01	.01	6.	1.01	17.45	213	.24	.24	.00	174.
1.01	6.50	70	.01	.01	.01	6.	1.01	17.50	214	.24	.24	.00	172.
1.01	6.55	71	.01	.01	.01	6.	1.01	17.55	215	.24	.24	.00	171.
1.01	6.00	72	.01	.01	.01	6.	1.01	18.00	216	.24	.24	.00	171.
1.01	6.05	73	.07	.04	.02	7.	1.01	18.05	217	.02	.02	.00	167.
1.01	6.10	74	.07	.04	.02	8.	1.01	18.10	218	.02	.02	.00	159.
1.01	6.15	75	.07	.04	.02	11.	1.01	18.15	219	.02	.02	.00	126.
1.01	6.20	76	.07	.05	.02	15.	1.01	18.20	220	.02	.02	.00	111.
1.01	6.25	77	.07	.05	.02	20.	1.01	18.25	221	.02	.02	.00	85.
1.01	6.30	78	.07	.05	.02	23.	1.01	18.30	222	.02	.02	.00	64.
1.01	6.35	79	.07	.05	.02	26.	1.01	18.35	223	.02	.02	.00	45.
1.01	6.40	80	.07	.05	.02	28.	1.01	18.40	224	.02	.02	.00	39.
1.01	6.45	81	.07	.05	.01	30.	1.01	18.45	225	.02	.02	.00	34.
1.01	6.50	82	.07	.05	.01	31.	1.01	18.50	226	.02	.02	.00	29.
1.01	6.55	83	.07	.05	.01	32.	1.01	18.55	227	.02	.02	.00	24.
1.01	7.00	84	.07	.05	.01	33.	1.01	19.00	228	.02	.02	.00	21.
1.01	7.05	85	.07	.05	.01	34.	1.01	19.05	229	.02	.02	.00	19.
1.01	7.10	86	.07	.05	.01	35.	1.01	19.10	230	.02	.02	.00	18.
1.01	7.15	87	.07	.05	.01	35.	1.01	19.15	231	.02	.02	.00	17.
1.01	7.20	88	.07	.05	.01	36.	1.01	19.20	232	.02	.02	.00	16.
1.01	7.25	89	.07	.05	.01	36.	1.01	19.25	233	.02	.02	.00	16.
1.01	7.30	90	.07	.05	.01	37.	1.01	19.30	234	.02	.02	.00	16.
1.01	7.35	91	.07	.06	.01	37.	1.01	19.35	235	.02	.02	.00	15.
1.01	7.40	92	.07	.06	.01	37.	1.01	19.40	236	.02	.02	.00	15.
1.01	7.45	93	.07	.06	.01	38.	1.01	19.45	237	.02	.02	.00	15.
1.01	7.50	94	.07	.06	.01	38.	1.01	19.50	238	.02	.02	.00	15.
1.01	7.55	95	.07	.06	.01	38.	1.01	19.55	239	.02	.02	.00	15.
1.01	8.00	96	.07	.06	.01	39.	1.01	20.00	240	.02	.02	.00	15.
1.01	8.05	97	.07	.06	.01	39.	1.01	20.05	241	.02	.02	.00	15.
1.01	8.10	98	.07	.06	.01	39.	1.01	20.10	242	.02	.02	.00	15.
1.01	8.15	99	.07	.06	.01	39.	1.01	20.15	243	.02	.02	.00	15.
1.01	8.20	100	.07	.06	.01	40.	1.01	20.20	244	.02	.02	.00	15.
1.01	8.25	101	.07	.06	.01	40.	1.01	20.25	245	.02	.02	.00	15.
1.01	8.30	102	.07	.06	.01	40.	1.01	20.30	246	.02	.02	.00	15.
1.01	8.35	103	.07	.06	.01	40.	1.01	20.35	247	.02	.02	.00	15.
1.01	8.40	104	.07	.06	.01	40.	1.01	20.40	248	.02	.02	.00	15.
1.01	8.45	105	.07	.06	.01	41.	1.01	20.45	249	.02	.02	.00	15.
1.01	8.50	106	.07	.06	.01	41.	1.01	20.50	250	.02	.02	.00	15.
1.01	8.55	107	.07	.06	.01	41.	1.01	20.55	251	.02	.02	.00	15.
1.01	9.00	108	.07	.06	.01	41.	1.01	21.00	252	.02	.02	.00	15.
1.01	9.05	109	.07	.06	.01	41.	1.01	21.05	253	.02	.02	.00	15.
1.01	9.10	110	.07	.06	.01	41.	1.01	21.10	254	.02	.02	.00	15.
1.01	9.15	111	.07	.06	.00	41.	1.01	21.15	255	.02	.02	.00	15.
1.01	9.20	112	.07	.06	.00	41.	1.01	21.20	256	.02	.02	.00	15.
1.01	9.25	113	.07	.06	.00	42.	1.01	21.25	257	.02	.02	.00	15.
1.01	9.30	114	.07	.06	.00	42.	1.01	21.30	258	.02	.02	.00	15.
1.01	9.35	115	.07	.05	.00	42.	1.01	21.35	259	.02	.02	.00	15.

1.01	9.40	116	.07	.06	.00	42.	1.01	21.40	260	.02	.02	.00	15.
1.01	9.45	117	.07	.06	.00	42.	1.01	21.45	261	.02	.02	.00	15.
1.01	9.50	118	.07	.06	.00	42.	1.01	21.50	262	.02	.02	.00	15.
1.01	9.55	119	.07	.06	.00	42.	1.01	21.55	263	.02	.02	.00	15.
1.01	10.00	120	.07	.06	.00	42.	1.01	22.00	264	.02	.02	.00	15.
1.01	10.05	121	.07	.06	.00	42.	1.01	22.05	265	.02	.02	.00	15.
1.01	10.10	122	.07	.06	.00	42.	1.01	22.10	266	.02	.02	.00	15.
1.01	10.15	123	.07	.06	.00	42.	1.01	22.15	267	.02	.02	.00	15.
1.01	10.20	124	.07	.06	.00	43.	1.01	22.20	268	.02	.02	.00	15.
1.01	10.25	125	.07	.06	.00	43.	1.01	22.25	269	.02	.02	.00	15.
1.01	10.30	126	.07	.06	.00	43.	1.01	22.30	270	.02	.02	.00	15.
1.01	10.35	127	.07	.06	.00	43.	1.01	22.35	271	.02	.02	.00	15.
1.01	10.40	128	.07	.06	.00	43.	1.01	22.40	272	.02	.02	.00	15.
1.01	10.45	129	.07	.06	.00	43.	1.01	22.45	273	.02	.02	.00	15.
1.01	10.50	130	.07	.06	.00	43.	1.01	22.50	274	.02	.02	.00	15.
1.01	10.55	131	.07	.06	.00	43.	1.01	22.55	275	.02	.02	.00	15.
1.01	11.00	132	.07	.06	.00	43.	1.01	23.00	276	.02	.02	.00	15.
1.01	11.05	133	.07	.06	.00	43.	1.01	23.05	277	.02	.02	.00	15.
1.01	11.10	134	.07	.06	.00	43.	1.01	23.10	278	.02	.02	.00	15.
1.01	11.15	135	.07	.06	.00	43.	1.01	23.15	279	.02	.02	.00	15.
1.01	11.20	136	.07	.06	.00	43.	1.01	23.20	280	.02	.02	.00	15.
1.01	11.25	137	.07	.06	.00	43.	1.01	23.25	281	.02	.02	.00	15.
1.01	11.30	138	.07	.06	.00	43.	1.01	23.30	282	.02	.02	.00	15.
1.01	11.35	139	.07	.06	.00	43.	1.01	23.35	283	.02	.02	.00	15.
1.01	11.40	140	.07	.06	.00	43.	1.01	23.40	284	.02	.02	.00	15.
1.01	11.45	141	.07	.06	.00	43.	1.01	23.45	285	.02	.02	.00	15.
1.01	11.50	142	.07	.06	.00	43.	1.01	23.50	286	.02	.02	.00	15.
1.01	11.55	143	.07	.06	.00	43.	1.01	23.55	287	.02	.02	.00	15.
1.01	12.00	144	.07	.06	.00	44.	1.02	0.00	288	.02	.02	.00	15.
									SUM	33.80	32.42	1.38	22516.
										(859.11	824.11	35.11	637.*M1

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	923.	251.	78.	78.	22516.
CMS	23.	7.	2.	2.	638.
INCHES		25.97	32.32	32.32	32.32
MM		658.37	820.95	820.95	820.95
AC-FT		124.	155.	155.	155.
THOUS CU M		153.	191.	191.	191.

HYDROGRAPH AT STAINHLOW FOR PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	4.	4.	6.	6.	10.	12.	13.	14.
15.	16.	16.	17.	17.	17.	18.	18.	18.	18.
19.	19.	19.	19.	19.	19.	19.	20.	20.	20.
20.	20.	20.	20.	20.	20.	20.	20.	21.	21.
21.	21.	21.	21.	21.	21.	21.	21.	21.	21.
21.	21.	21.	21.	21.	21.	21.	21.	21.	21.
21.	22.	22.	22.	22.	22.	22.	22.	22.	22.
22.	22.	22.	22.	23.	26.	33.	42.	51.	58.
63.	67.	69.	71.	72.	73.	74.	76.	77.	81.

Output Summary
Various PMF Events
Wells Lake Dam
MO 30906

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .50	RATIO 2 1.00
HYDROGRAPH AT	INFLOW	.09	1	411.	823.
	1	.231	1	11.651I	21.301I
ROUTED TO	DAM	.09	1	294.	677.
	1	.231	1	8.321I	19.161I

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	879.90	879.90	882.60
STORAGE	109.	109.	132.
OUTFLOW	0.	0.	534.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	882.03	0.00	127.	294.	0.00	16.17	0.00
1.00	882.58	.28	134.	677.	.99	16.09	0.00

Output Summary
Various PMF Events
Wells Lake Dam
MO 30906

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO APPLIED TO FLOWS			
				RATIO 1 .91	RATIO 2 .92	RATIO 3 .93	RATIO 4 .94
HYDROGRAPH AT	INFLOW	.09	1	666.	675.	683.	691.
		.231		18.857[illegible]	19.101[illegible]	19.341[illegible]	19.571[illegible]
ROUTED TO	DAM	.09	1	530.	538.	546.	554.
		.231		15.000[illegible]	15.231[illegible]	15.461[illegible]	15.691[illegible]

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	879.00	879.00	892.60
STORAGE	109.	109.	132.
OUTFLOW	0.	0.	534.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE ACRE-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.91	892.59	0.00	132.	530.	0.00	16.08	0.00
.92	892.81	.01	132.	538.	.08	16.08	0.00
.93	892.62	.02	132.	546.	.08	16.08	0.00
.94	892.64	.04	132.	554.	.25	16.08	0.00

Output Summary
Various PMF Events
Wells Lake Dam
MO 30906

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APPENDIX C

Soil Conservation Service Design Notes

Mr. Charles Wells
RFD 1 Box 78
Bonne Terre, Mo. 63628

May 9, 1972

Dear Charles:

The following is a report of the investigation made by our engineer on May 5, 1972.

He reports that two dams may be desirable, one on each draw, to avoid Class 1 specifications. One large dam below the junction would certainly be Class 1. It can be done, but at high cost.

Limestone outcrops are badly weathered and a deep core into limestone bedrock is likely to be required. There is no way to predict depth accurately.

Our engineer has requested a geologic investigation. I hope this will be in the very near future. I will keep you posted.

Yours very truly,

Leon Everly
District Conservationist
Soil Conservation Service
Box 108
Farmington, Mo. 63640

MO-ENG-4.0
12/70
(File Code ENG-13)

P. I. Est.

UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

DESIGN SHEET FOR CLASS II, III, IV * DETENTION STORAGE STRUCTURE
WITH DROP INLET SPILLWAY -- HOOD INLET SPILLWAY -- CANOPY INLET SPILLWAY *

Landowner Charles Wells Location _____

Design by _____ Date _____ Checked by _____ Date 4/20/72

Drainage area = 480 ac. Height X storage = _____ X _____ = _____

WATERSHED CONDITIONS AND FACTORS

Location factor: L = 1.0

Infiltration factor: (~~above~~) (average) (~~below~~) * I = 1.0

Topographic factor: 8 % average slope T = 1.0

Shape factor: runoff distance = 6200 ft. S = 1.1

Cover factor: cropland — %, pasture 60 %, timber 40 % V = 0.7

Contouring factor: C = 1.0

Storage factor: _____ % terraced P = 1.0

PEAK RATE OF RUNOFF AND VOLUME OF RUNOFF

Product of factors = L X I X T X S X V X C X P = 7.7 use > 8 Q_{10} = 651 c.f.s.

V X I = 0.7 X 1.0 = 0.7

For Principal Spillway Design:

10 -year peak rate of runoff = Q_{ip} = 1.0 X 651 c.f.s. = 651 c.f.s.

Rate of volume of runoff = 0.10 ac.ft./ac. (Table 1, 1519)

Total volume of runoff = V_{rp} = (drainage area) X (rate of volume of runoff) X L =

480 ac. X 0.10 ac.ft./ac. X 1.0 = 480 ac.ft.

For Both Spillways (total structure):

50 -year peak rate of runoff = Q_i = 1.5 X 651 c.f.s. = 977 c.f.s.

Rate of volume of runoff = .17 ac.ft./ac.

Total volume of runoff = V_r = 480 ac. X .17 ac.ft./ac. X 1.0 = 81.6 ac.ft.

* Mark out those items that do not apply.

Instructions for use of form: Make one pencil copy for applicable structure. File with other worksheets and structure plan in cooperator's or landowner's folder in work unit office.

MP ENG-15 (Formerly MO-69 & MO-248)
5\ /69

Date 4/20/72
By _____ Ck _____

U.S. DEPARTMENT OF AGRICULTURE - SOIL CONSERVATION SERVICE - COLUMBIA, MO.

EARTH WORK COMPUTATION SHEET

Owner or Watershed Charles Wells — Location or Sub-Watershed _____ Structure Number _____

Top of Fill; Width 12 ; Elev. 109.3 ; Slopes - Upstream 4:1 Downstream 2:1

6.3 Ac. Surface

Upstream Berm: Width _____ Elev. _____; Downstream Berm: Width _____ Elev. _____

Station	Ground Elev. at ℄	Fill Hgt. Ft.	Fill Yd.3/ Ft.	Berm Hgt. Ft.	Berm Yd 3/ Ft.	Berm Hgt. Ft.	Berm Yd 3/ Ft.	Total Fill Yd3/Ft.	Sum Fill	Dist. Between Sta.	Double Fill Yd. 3
									XXXXXXXX	XXXXXXXXX	XXXXXXXXX
0+00	107.3	0.0	0.0					1.0	1.0	20	20
1+00	107.7	1.6	1.0					5.4	5.4	50	270
1+50	104.7	4.6	4.4					18.9	18.9	50	945
2+00	99.7	9.6	14.5					43.6	43.6	50	2180
2+50	95.0	14.3	29.1					68.0	68.0	50	3400
3+00	92.5	16.8	38.9					81.2	81.2	50	4060
3+50	91.7	17.6	42.3					91.8	91.8	20	1836
3+70	90.1	19.2	47.5					111.0	111.0	12	1332
3+82	87.7	21.6	61.5					123.5	123.5	8	988
3+90	87.6	21.7	62.0					97.1	97.1	10	971
4+00	93.4	15.9	35.1					47.4	47.4	50	2370
4+50	100.6	8.7	12.3					13.9	13.9	40	556
4+90	107.0	2.3	1.6							410'	
						Total Double Fill			XXXXXXXX	XXXXXXXXX	XXXXXXXXX
						Total Fill					18,928
											9,464

Allow _____ % for Settlement. . . . . _____
Side Spillway Fill (Including Dikes) _____
Backfill Core Trench Exc. . . . . _____
Backfill Structure Exc. . . . . _____
Backfill Stripping . . . . . _____
Class _____ Total . . . _____

END

DATE
FILMED

11-81

DTIC